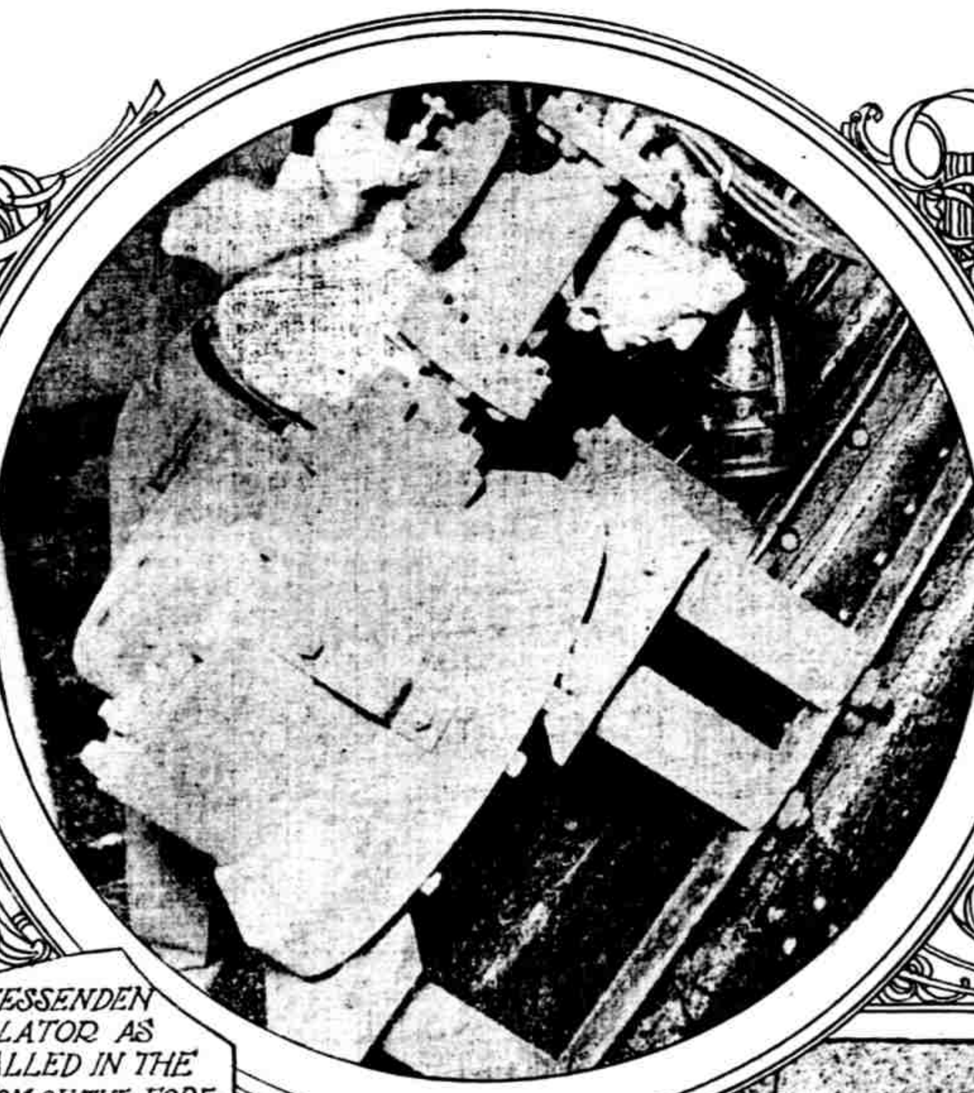
DOING THE IMPOSSIBLE

Twentieth Century Marvels

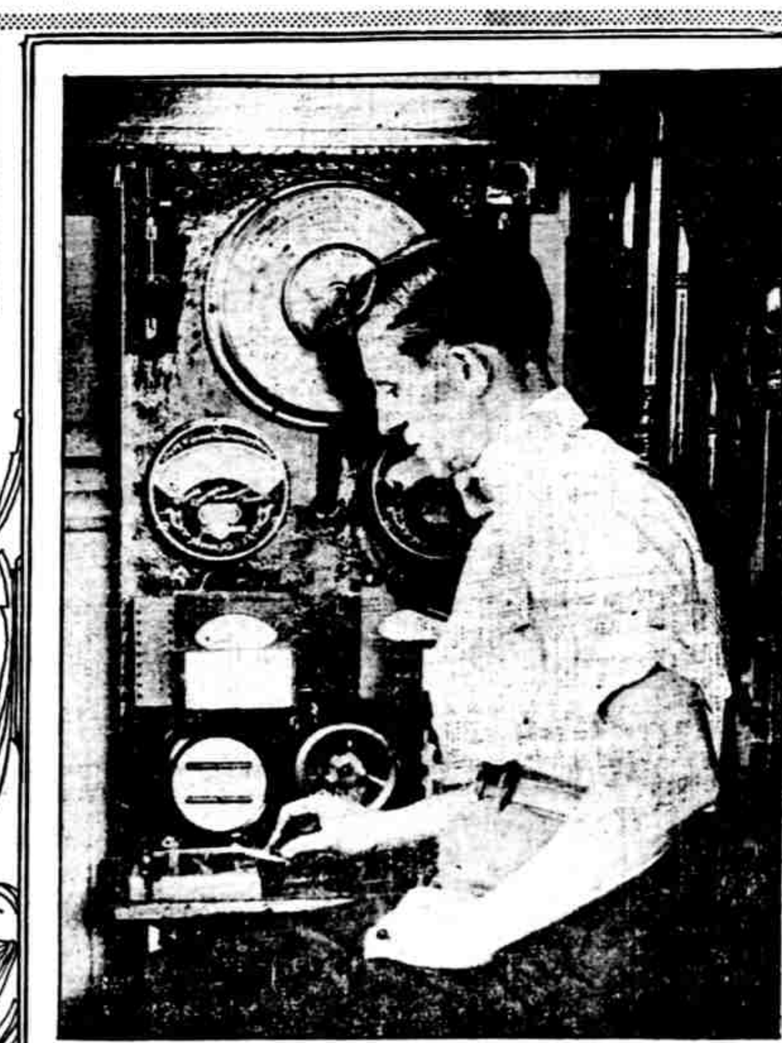
By CLEVELAND MOFFETT

The Electrical Ear and Water Wireless

PROFESSOR R. A. FESSENDEN IN HIS LABORATORY. ELECTRICAL ICE DETECTOR SHOWN AT LEFT.



THE FESSENDEN OSCILLATOR AS INSTALLED IN THE BOTTOM OF THE FORE-PEAK OF THE COAL BARGE DEVEREUX.



OPERATOR DANNY PRICE AT KEY OF WATER WIRELESS SWITCHBOARD ON BOARD THE COAL BARGE DEVEREUX

EXTERIOR VIEW OF THE ELECTRICAL EAR.

ABOUT the middle of December, 1914, there returned from abroad an American inventor, Prof. R. A. Fessenden, who reported to his associates in the Submarine Signal Company of Boston, Mass., that one of the great European powers (I am not at liberty to say which one), after thorough tests, had decided to equip several of its battleships with the Fessenden electric oscillator, an instrument that promises to change the conditions of naval warfare, especially the relations of battleships and submarines.

He announced, furthermore, that another great power was in active negotiation for this American invention, the practical value of which will probably be demonstrated with startling effect in one of the not-distant sea battles.

Not only will this electric oscillator be of immense importance in time of war, but it bids fair to render still greater service in time of peace by insuring ships against collisions at sea, either with one another or with icebergs. Recent tests by the United States revenue cutter Miami demonstrated this latter point in a memorable cruise through the iceberg region of the banks of Newfoundland, during the month of April, 1914.

A Water Wireless.

To put it simply, this Fessenden oscillator is a submarine sounding apparatus that sends its signals through the water, not through the air, one result being that these signals travel more swiftly than they would through the air, since sound moves through water at the rate of 4,100 feet a second, while through the air it moves at the rate of only 1,100 feet a second.

All seafaring men know the untrustworthiness of sound warnings sent through the air from steam whistles, or steam sirens. These warnings are often unheard even at a very short distance, say one mile or less, owing to adverse wind conditions, or to disconcerting "holes in the air," or to unfavorable reflections or skippings of the sound from the water's surface. For this reason submarine bells have for years been used with excellent results on lightships and buoys, and to some extent on moving vessels, their warnings being transmitted for miles through the water.

In fact, it was in trying to extend the usefulness of these submarine bells, especially in connection with ships, that Prof. Fessenden evolved his present electric oscillator, and solved the whole problem of protecting vessels from collisions at sea. His system of submarine signaling is really a kind of water wireless, destined, perhaps, to as important a development as the aerial wireless.

A Modern Wonder Worker.

A few weeks ago in Boston I had a talk with Prof. Fessenden about his invention at the factory of the Submarine Signal Company, a grimy and resounding establishment, the birthplace of submarine bells, scores of which are now clanging forth their warnings under the sea, electrically or pneumatically, on buoys or lightships spaced along the perilous ocean fringes of many lands.

I found the professor in a laboratory room filled with strange apparatus, electrical instruments, a model of his improved iceberg detector, and various other indications of an inventive mind.

All his life Prof. Fessenden has been an active explorer in new fields of knowledge. For years he was associated with Thomas A. Edison. He was one of the pioneers in wireless telegraphy, and his system of wireless transmission is used in the great Arlington towers at Washington, D. C. Also his system of electric power transmission was used by the Canadian government in distributing the energy of Niagara Falls through the Province of Ontario. For years he was professor of electricity and physics at the University of Pittsburgh. I have never met a man more keenly interested in more different kinds of things.

A Warning Voice.

In one corner of the factory, in a fenced-off space, we came to the new-born oscillator, a smallish metal affair, no bigger than a sewing machine, with many copper parts for the electrical connections and a drumhead of solid steel, twenty-two inches in diameter and five-eighths of an inch thick, that vibrates astonishingly under the electric current and gives forth a sound of terrifying loudness.

"Would you like to hear it?" asked the professor. Then turning to an assistant, "Are you ready?"

He switched on a buzzing generator, adjusted a rheostat, pressed a black key, whereupon—"Whoo-oop!" the thing barked at us suddenly like an angry calliope, and the tone persisted as long as the key was held down. A shift of the rheostat handle brought a current of greater frequency and the tone rose to a piercing shriek.

Another turn and the shriek was deafening. Louder and shriller screamed the quivering drumhead as the scientist manipulated the rheostat handle in the manner of a motorman speeding up his trolley car. The whole factory resounded. I covered my ears and waved for mercy.

"But it will be unendurable on a ship, a thing like that, sounding all the time," I said.

The inventor shook his head. "When you hear the oscillator sounding on a vessel you will scarcely notice it. Here we are right at the source of the sound, but on a ship the oscillator is deep down in the hold and is submerged in water. You will see."

In Naval Warfare.

Prof. Fessenden then showed me a gray steel tank like a big bathtub, with ends made of steel plates, such as are used in battleships. Experiments have been made with this tank filled with water and the oscillator welded to one end, so that the vibrations pass through the liquid.

"When we sound the oscillator in this way," he said, "the water in the tank is thrown into a state of extraordinary agitation, so much so that if you dipped your hand in during the experiment it would be hurled out violently and painfully. I scarcely know whether this shock is physical or electrical. It is due to the fact that under the rapid and powerful impact of the vibrating end plate the mass of liquid is literally squeezed together about a thousandth of an inch for each vibration, and then torn apart. One thousandth of an inch is an enormous amount when you reflect that water is practically incompressible. It is almost as if the atomic structure of the water had been twisted or distorted."

"Would these vibrations be transmitted through the water to a considerable distance?" I asked.

"To a very considerable distance. We have already received them at a distance of thirty-two miles, but that is only a beginning—like the first wireless message sent across the English Channel, which seemed wonderful fifteen years ago, but is nothing today."

"Do you think it will be possible to transmit these water vibrations over, say, a hundred miles?"

"I have no doubt of it, perhaps several hundred miles, with larger oscillators and more powerful currents."

"And you will be able to send messages in this way through the water itself with no wires or cables?"

"Exactly. It is simply a matter of making the oscillator toot out dots and dashes according to the code. Now, you see the importance of these oscillators in naval warfare, for a battleship equipped with such instruments can talk to its own submarines while they are miles away and submerged and can actually direct their movements against an enemy's vessels."

A Revolutionary Development.

"Without the submarines being obliged to come to the surface?"

"They need not come up until just before launhing their torpedoes, say at a distance of a thousand yards from the vessel they wish to attack. Then they will only show their periscopes for a few seconds while they make final observations."

"And then launch their torpedoes?"

"Yes."

"It's a revolutionary development isn't it?"

"You are not the first one to express that opinion," smiled the professor. "Some big authorities think it will change our whole naval strategy."

"But this has never been actually accomplished, has it, the control of submerged submarines from a battleship?"

"Not yet, but it soon will be accomplished. We have already put oscillators on several American battleships, on the Wyoming, the Delaware, the Utah, the Florida, and on four of the United States submarines—the D-1 and D-2, the K-1 and K-2—and we are now installing them on battleships of a great foreign power."

I asked about the method of listening at a distance to these water wireless signals, and Prof. Fessenden explained that thi may be done in a temporary way with the help of a microphone lowered, for instance, from a lightship, or from a vessel at anchor. This microphone is connected with an ordinary telephone headpiece, through which a listener on the deck may hear signals sent through the water by an oscillator miles away.

"As a permanent listening arrangement," continued the inventor, "we use the oscillator itself, which is really a kind of telephone. I'll show you what I mean. Suppose you say something, anything you please, to this steel diaphragm after I have gone out."

A Satisfactory Test.

With this the professor went into another room, and I recited, "Mary had a little lamb" to the oscillator and then counted slowly up to nine. Whereupon I heard the inventor's voice issuing distinctly from the disk of steel and repeating word for word what I had said.

Standing in the next room, he had heard my remarks to the steel diaphragm through a telephone connection, and had spoken back to me by this telephone. In other words, the minute vibrations of my voice and of his voice had been sufficient to set that thick metal plate quivering so that audible words were transmitted through it in either direction.

"So you see," resumed the professor on his return, "a vessel equipped with a set of oscillators may use them both for sending and for receiving."

"Does a vessel need more than one oscillator?"

"Yes, it needs two, like two ears, one on either side, which allows it to fix the direction from which a signal comes. This is done by a delicate instrument that takes account of differences in the intensity of a given signal as heard by the two electrical ears, one of which, on the more favorable side, hears the signal more distinctly than the other. A ship's officer has only to adjust this instrument and then read off on a dial the exact point of the compass from which the signal comes."

"Then a battleship, as it receives water wireless signals from one of its own submerged submarines, could tell in what direction that submarine lay?"

"Within a few degrees, yes. In such experiments our errors in fixing the direction have not usually exceeded half a point of the compass."

"How about the distance of a submerged submarine from a battleship—could the battleship tell that?"

"Yes, approximately, by the intensity of the sound received, for, of course, the oscillator's loudness grows less as the distance increases. There will be a distance indicator with a dial graduated in thousands of yards, and an officer will read off these distance indications just as he notes the points of the compass. Besides this, a battleship will get precise information from the submarine herself—I mean a friendly submarine—by talking with her in code, by asking questions as to her speed, direction, distance below the surface, etc."

Safety for Battleships.

From all of this it is plain that a battleship which can thus control the movements of submerged submarines has an enormous advantage over the ships of an enemy. A single cruiser, aided by half a dozen deadly craft, steaming far below the surface and able to maneuver safely on the lower levels, at the bidding of the mother ship, might easily wipe out a whole squadron of dreadnaughts unprotected against this new danger. With oscillators aboard, a battleship becomes an eye to see, a brain to guide, while the submarines, moving, sightless, through the deep, black waters, are arms that strike and destroy unerringly according to orders from above.

"Your invention increases the terrors of the submarine?" I continued. "It leaves the dreadnaught practically helpless?"

The professor shook his head. "That is true for dreadnaughts not equipped with oscillators, but for others that are able to listen with electrical ears, the submarine becomes far less formidable. The oscillator makes it possible for a ship's officer to hear the propeller movements of an enemy's submarine while it is miles away. With our existing apparatus we can detect such propeller sounds at a distance of two miles, and we have a sound amplifying device that will extend this distance to five miles or more."

"Does that mean safety for battleships from submarine attack?"

"A great measure of safety, yes."

"Then those three British cruisers that were sunk by German submarines could have escaped if they had carried these listening oscillators?"

"Unquestionably."

"What would they have done?"

"As soon as they heard the propellor noises of the attacking submarines, which would have been some time before the German torpedoes were launched, they would have changed their courses and gone ahead at full speed. That would have baffled the enemy, for submarines are slow-going craft and only dangerous when their presence is not suspected. It is even possible that the British cruisers, knowing by dial indications the approximate distance and direction of the submerged German vessels, could have destroyed them by launching torpedoes of their own."

A Convincing Experiment.

An illustration of the fact that the propeller and engine sounds of a submerged submarine may be detected by a distant vessel running along the ocean surface was furnished several years ago when the Submarine Signal Company actually demonstrated the thing in Newport harbor at the request of a United States naval officer.

"Do you mean to tell me," asked the incredulous officer, "that if one of our submarines submerges and runs back and forth out of sight on the lower levels, you can hear her in a vessel at the surface and follow her by means of your listening apparatus?"

"Certainly we can," said the signal man. "Go ahead and sink your submarine. I'll show you."

So they made the test, and for some time a swift launch equipped with water wireless microphones circled and zigzagged about Newport harbor guided by sounds from the depths picked up and magnified by the electrical ears.

"You're wrong! You've lost her," declared the officer presently. "The submarine is nowhere near here. I know the course she was to take."

The signal man insisted he was right, however, and a little later the submarine came to the surface at the very spot indicated by the listening apparatus. The officer was mistaken—and convinced.

I asked where the electrical oscillators are placed on a vessel, and learned that this point is somewhat forward of amidships and three or four fathoms under water, the exact location depending upon the lines of the hull. For example, in the case of the United States Utah oscillators were placed about half way between the bow and amidships and about twenty-three feet below the water line. The deeper the oscillators are in the water, the better is the sound transmission, since there is less interference from surface disturbances.

Some Earlier Tests.

Before coming to some remarkable tests of the Fessenden oscillator made by the United States navy in the summer of 1914 on two of its submarines, it may be well to mention other tests during the preceding years, which show the difficulties and disappointments that often attend the development of a great invention.

The summer of 1913 found all going well in the laboratory experiments and it was decided to try the oscillator practically on a large vessel. Arrangements were accordingly made with the United States navy authorities, and oscillators were placed aboard the battleships Delaware and Wyoming, and extensive tests were made in August and September during the Fisher's Island maneuvers.

Later in the same year oscillators were placed aboard the submarines D-1 and D-2, and tests were made at Hampton Roads off the Virginia capes. Much time and effort were consumed in these experiments and high hopes were raised, but when the final achievement was considered the result was found to be unsatisfactory. The signal did not carry to the expected distance and, on the whole, the new oscillators were not found superior to the old submarine bells.

Disappointed and perplexed, yet confident that his basic idea was sound, Prof. Fessenden went back to the factory for weeks of further investigation. What was the matter? Why had his oscillator signals carried only three or four miles, when they should have carried fifteen or twenty miles? Why? Suddenly the answer flashed out of the turmoil in the inventor's brain. He saw that the oscillators had been welded fast inside the steel skin of the battleships and inside of the steel ribs of the submarines, with the result that they had been forced to vibrate against masses of restraining metal that were not in the same phase or period of vibration with themselves; in other words, the oscillators were out of tune with these steel plates and steel ribs, consequently their vibrations suffered a great drag in passing through this opposing steel skin, and were much weakened when finally they struck the water. The remedy lay in attaching the oscillators to steel plates that would vibrate in unison with them. Accordingly a properly tuned steel plate in the form of a disk was made and attached to the oscillator, this being the steel drumhead already described.

A New Demonstration.

A new demonstration of this modified oscillator was made in Massachusetts Bay toward the end of January, 1914. An old wooden wrecking tug, the Susie D., was equipped with a steam turbine and generator for furnishing current to the new oscillator, also with a derrick and boom for lowering the heavy apparatus into the sea. A switchboard was set up on deck and, when everything was ready and the weather favorable, the Susie D. was moored fast to the Boston lightship at the mouth of the harbor. Then a powerful ocean-going tug, the Neponset, with Prof. Fessenden and Mr. J. F. Perkins, vice president of the company, and assistants aboard, steamed out into the ocean to see how far away they could pick up the signals with their microphone receiving apparatus. It was after 12 o'clock when they started, and the understanding was that Mr. Vaux, the sending operator on the Susie D., would keep his oscillator tooting twice a minute for five hours. Two miles out the Neponset stopped her engines and the microphones were lowered into the sea. It was impossible to listen while the tug was moving because of the slap of the waves and the interference of foreign noises. As the boat came to rest, Prof. Fessenden slipped on the telephone head set and listened.

"Tooooooot-toot-toot—" came the signal, and again after half a minute, "Toot-toot-tooooooot—"

"Fine!" beamed the inventor. "He's sending D. W's. It's clear as a bell."

At four miles they stopped again and and listened, then at six miles, then at eight, then at sixteen, and finally at twenty-five miles. Each time the signals from the Susie D. were heard distinctly. Every one of the party heard them, there was no doubt of it.

"At sixteen miles and at twenty-five miles," said Mr. Perkins, relating the experience, "the signals were so plain that you could hear them with the telephone receiver a foot away from your ear."

Suddenly a squall and snow storm came up, but the tug pushed on until they heard the Peaked Hill bell buoy sounding on their starboard, and this is thirty-one miles from the Boston lightship. In a whirl of snow flakes they stopped and listened for the last time—the five hours was nearly up and night was coming on—and here again they caught the submarine tootings of the Susie D. a little fainter, but quite unmistakable. Thirty-one miles by water wireless!

A Check to Sea Horrors.

Coming to the general future of this invention, its many advantages insure its wide adoption on vessels of all sorts. In fogs and dangers of the night every ship will sound its code letter two or three times a minute, thus revealing its identity to other ships miles away. And the location and distance of each vessel will be made known by the automatic swing of an electric needle mounted beside the compass—the greater the swing on a graduated dial, the less the distance. This means no more collisions like that on the St. Lawrence, when the Empress of Ireland went down. The Empress of Ireland would have been talking that night to the other ships, listening to her signals and steering accordingly, if they had both carried water wireless oscillators.

As to icebergs, the echo method insures safety, since it indicates distance and direction, as already explained. The Titanic would have known (by an electric indicator) the precise direction and distance of that tragic iceberg while she was still three miles from danger. As to the perils of shoals and reefs along regularly navigated coasts, it is plain that a line of oscillator stations placed at intervals, as lighthouses and bell buoys are placed, and sounding forth water wireless code signals at brief intervals in bad weather or at night woul create a continuously sounding zone of safety, reaching ten or twenty miles out to sea, and making it practically impossible for vessels to drive upon the rocks.

During my stay in Boston I witnessed a demonstration of this important submarine signaling work on board an ocean-going collier, the Devereux, a long iron vessel that plies down the coast to Norfolk, and unquestionably the most scientific collier in existence, being equipped with three oscillators and used regularly for sending and receiving water wireless messages.

I stood in the captain's cabin on the Devereux, beside the switchboard, while Operator Danny Price sent wireless signals pulsating through the depths of Boston harbor out to the tug Le Baron H. Jenkins—listening miles away with microphones overboard—and then out into the sea beyond. The turn of a brass wheel and the throw of a switch connected him with one or the other of the oscillators, or with two at a time. Price glanced at his voltmeters and ammeters, then pressed a key.

"Toooooooo-toot-toot," answered one of the steel diaphragms eighteen feet below the water line. Up here on deck it was like a boy's wooden whistle, rather low-pitched and musically pleasant, but a Swedish sailor known as Charley, who happened to dive overboard while the oscillator was sounding, declared that it nearly split his "noodle." All sounds are greatly intensified under water.

I myself had the experience of both listening and sending. I spelled water wireless signals in dots and dashes and heard them go forth, and I caught answering messages that came vibrating among the islands and shoals and flashing lights of the harbor.

Darkness was coming on as the old barge with her red and black hull steamed past the spar buoy of Nash's Rock and came abreast with Boston Light, and I reflected that all these vessels lying about us were safer than they had ever been from dangers of the sea because of this invention.